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Sharma et al.

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(54) **FREEFORM GRADIENT STYLE TRANSFER**

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G06T 11/40	(2006.01)
G06T 7/90	(2017.01)
G06T 7/60	(2017.01)
G09G 5/02	(2006.01)

(52) **U.S. Cl.**
CPC ***G06T 11/40*** (2013.01); ***G06T 7/60*** (2013.01); ***G06T 7/90*** (2017.01); ***G06T 11/001*** (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

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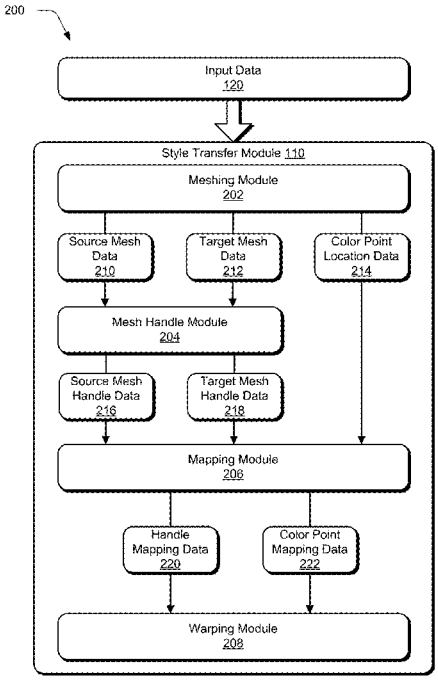
(57) **ABSTRACT**

In implementations of freeform gradient style transfer, a style transfer system transfers a style of a freeform gradient of a source geometry of an object to a target geometry of an additional object. The system adds source mesh handles to a boundary of a source mesh of the object, and the system also adds target mesh handles to a boundary of a target mesh of the additional object. The source mesh handles are mapped to the target mesh handles, and the system warps the source mesh to appear as the target mesh based on the mapping. Color point locations of the freeform gradient are mapped from the source mesh to the warped source mesh to transfer the freeform gradient style from the source geometry of the object to the target geometry of the additional object.

20 Claims, 10 Drawing Sheets
(7 of 10 Drawing Sheet(s) Filed in Color)



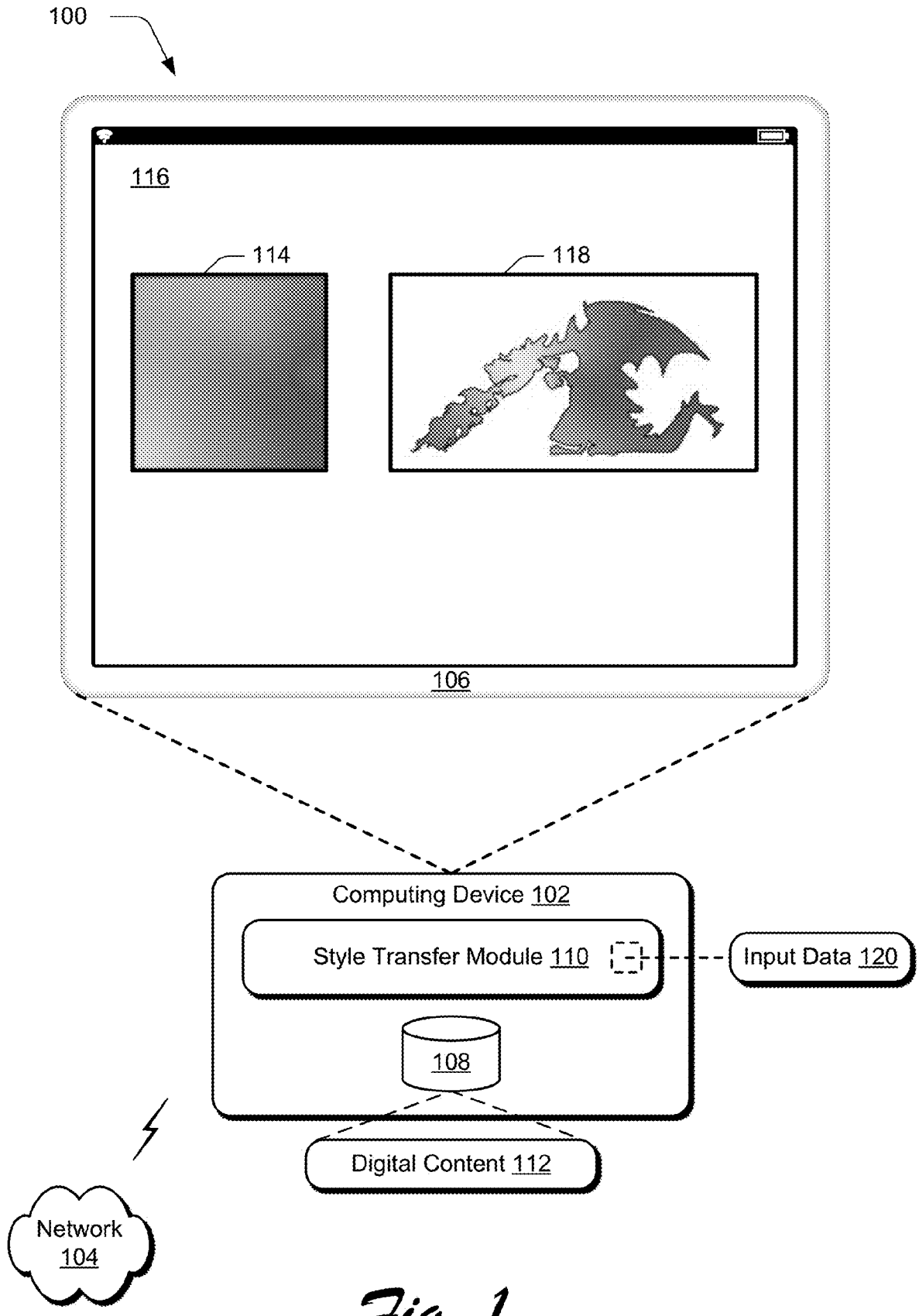

100
116
114
118
106
Computing Device 102
Style Transfer Module 110
Input Data 120
108
Digital Content 112
Network
104

Fig. 1

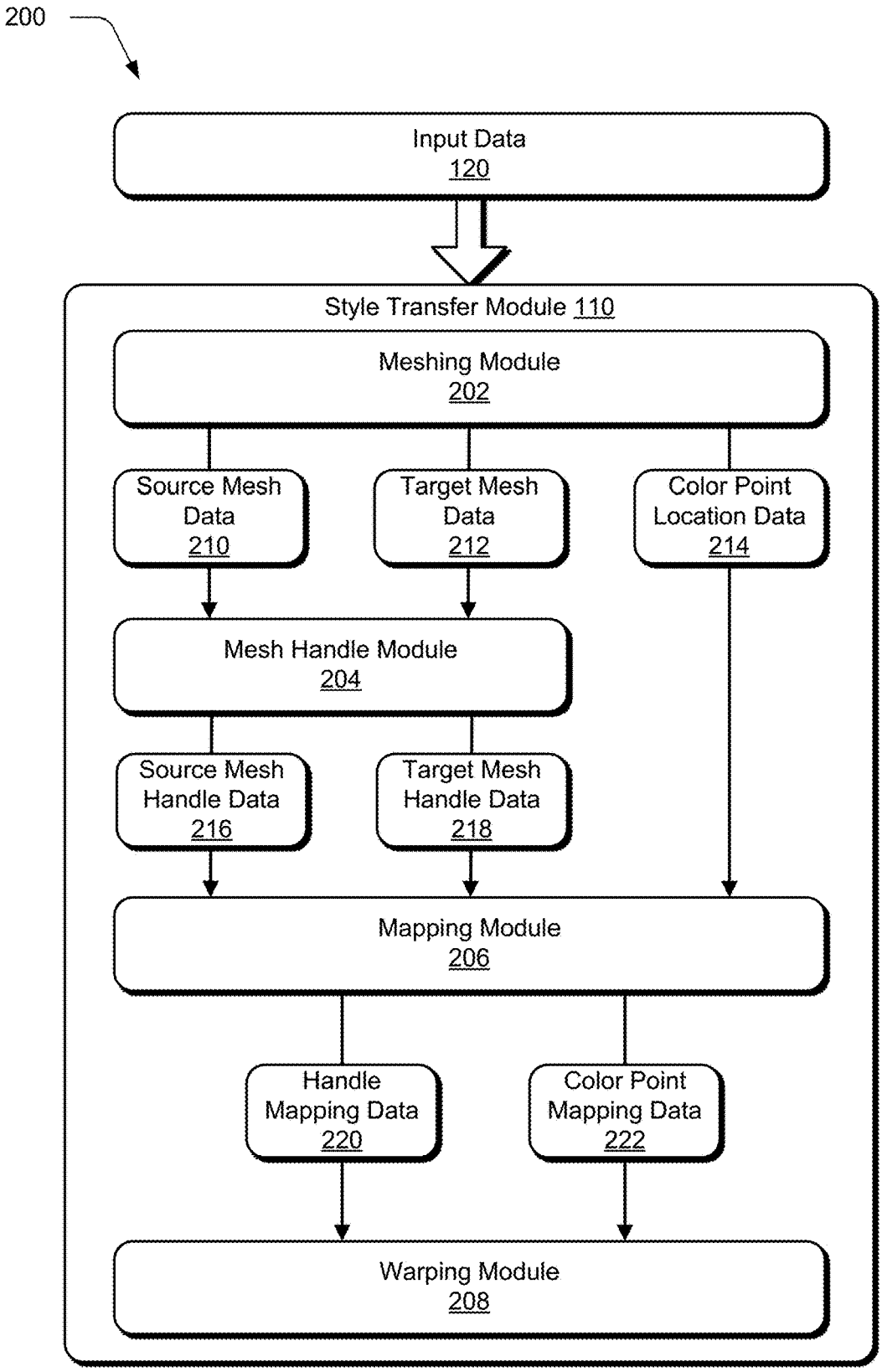

200
Input Data
120
Style Transfer Module 110
Meshing Module
202
Source Mesh Data
210
Target Mesh Data
212
Color Point Location Data
214
Mesh Handle Module
204
Source Mesh Handle Data
216
Target Mesh Handle Data
218
Mapping Module
206
Handle Mapping Data
220
Color Point Mapping Data
222
Warping Module
208

Fig. 2

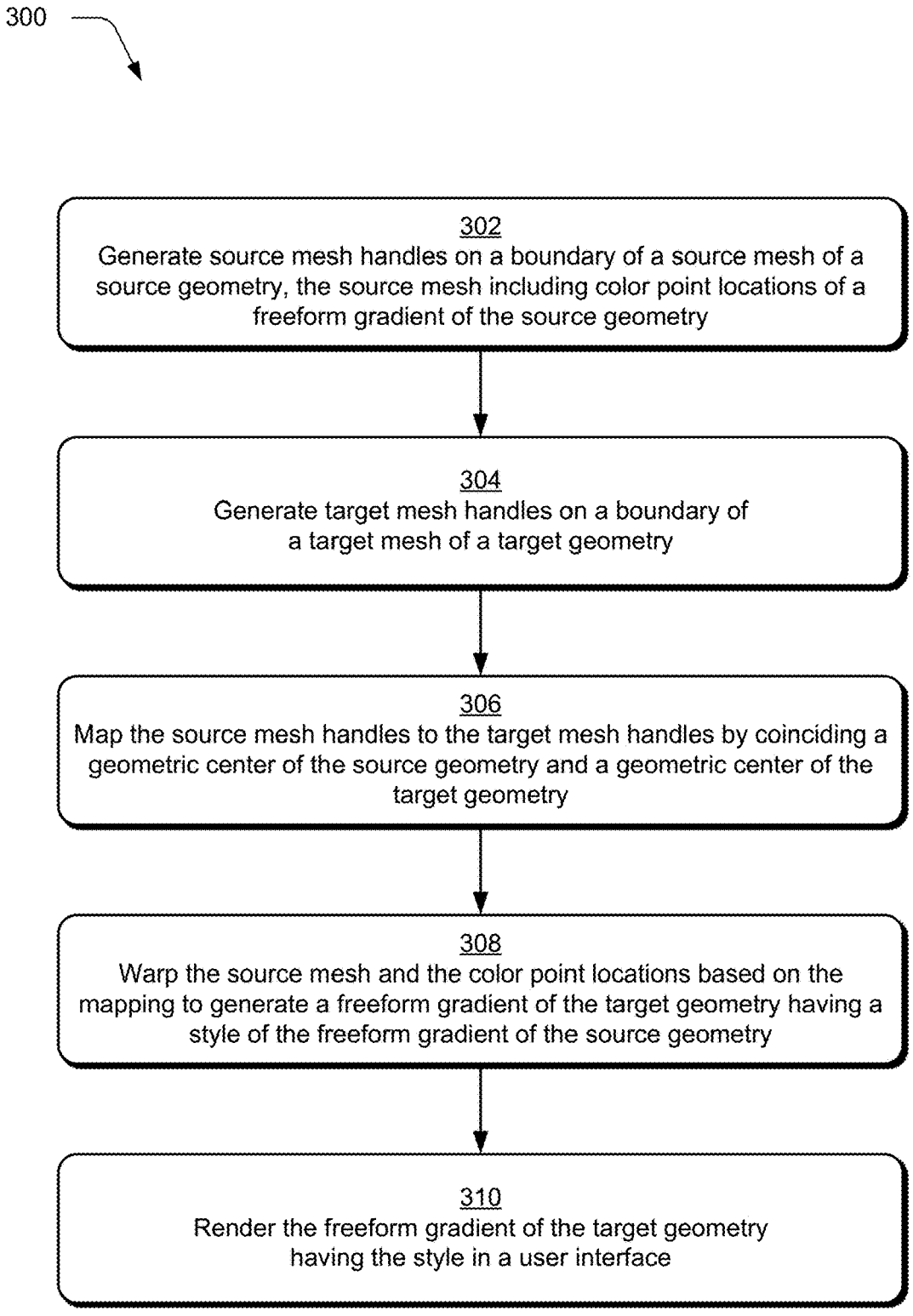

300
302
Generate source mesh handles on a boundary of a source mesh of a source geometry, the source mesh including color point locations of a freeform gradient of the source geometry
304
Generate target mesh handles on a boundary of a target mesh of a target geometry
306
Map the source mesh handles to the target mesh handles by coinciding a geometric center of the source geometry and a geometric center of the target geometry
308
Warp the source mesh and the color point locations based on the mapping to generate a freeform gradient of the target geometry having a style of the freeform gradient of the source geometry
310
Render the freeform gradient of the target geometry having the style in a user interface

Fig. 3

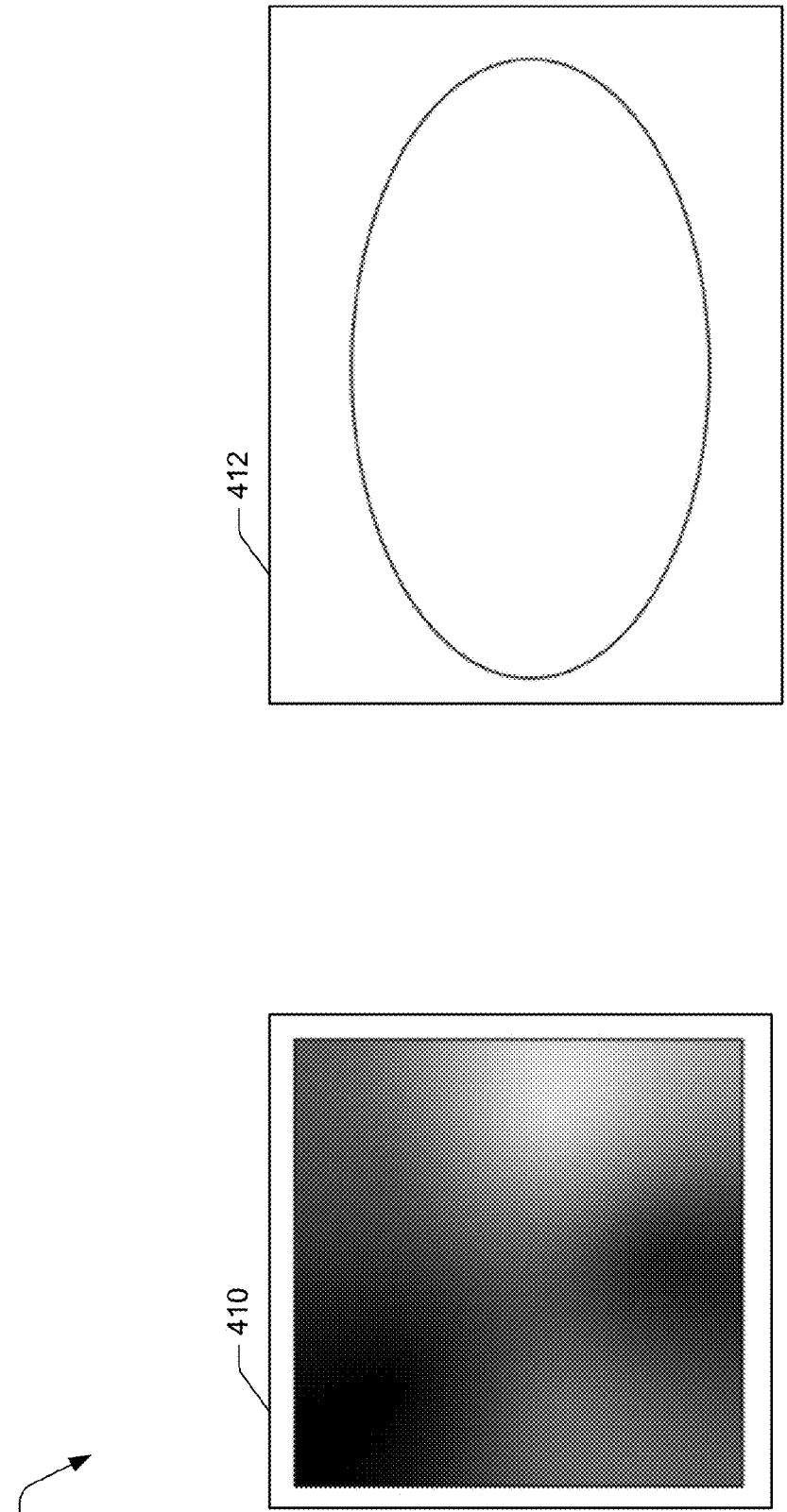


Fig. 4A

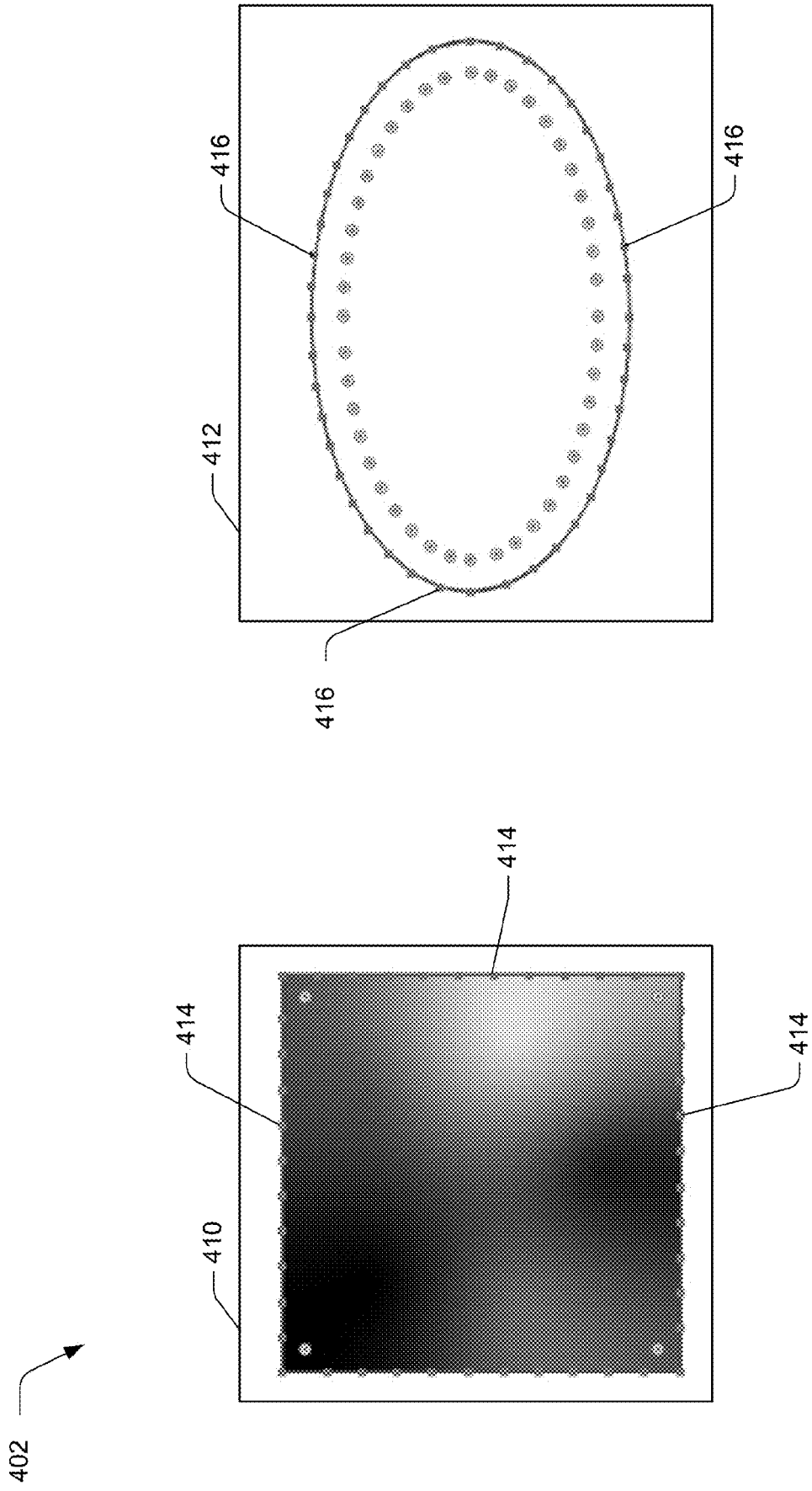


Fig. 4B

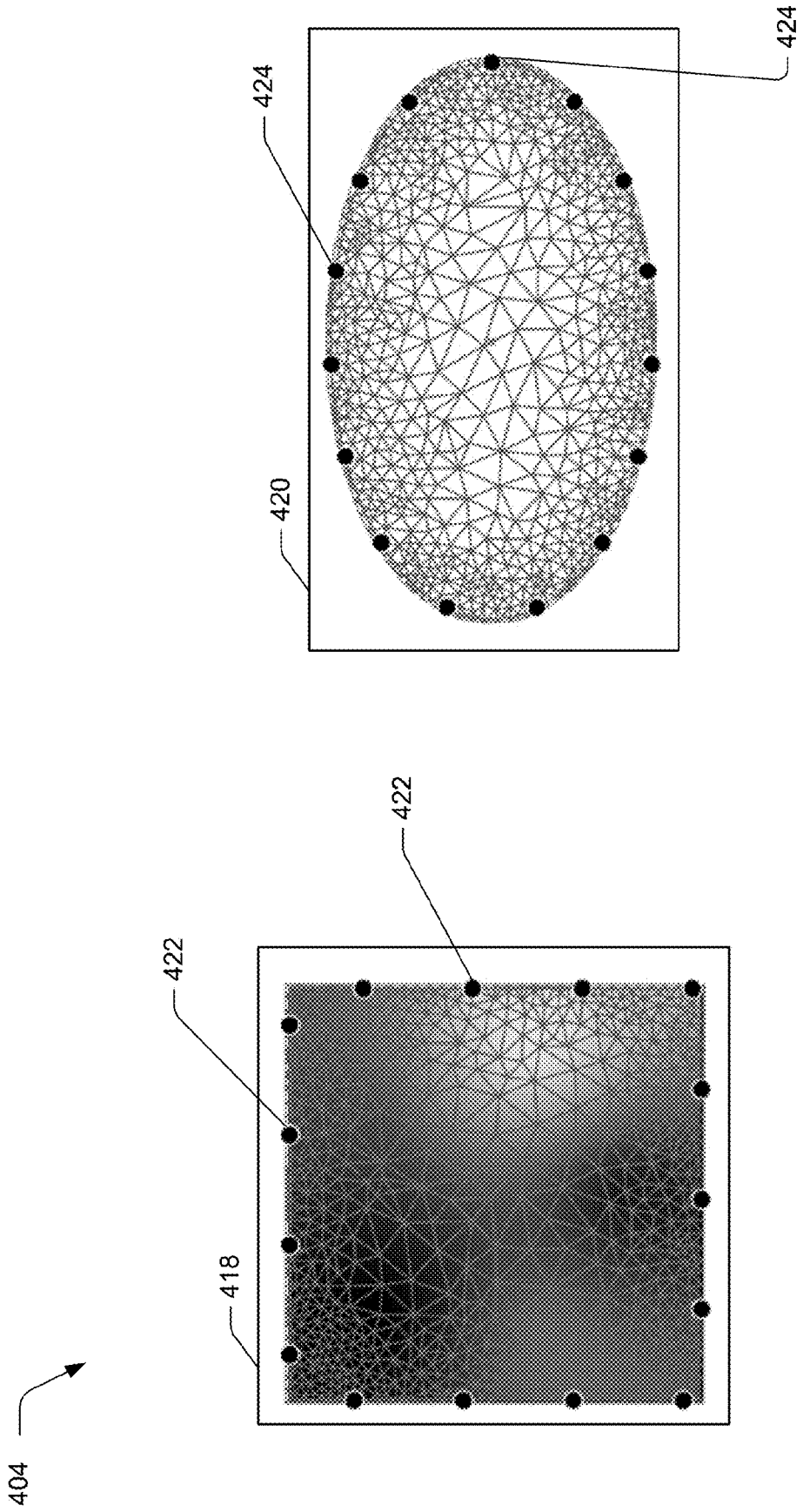


Fig. 4C

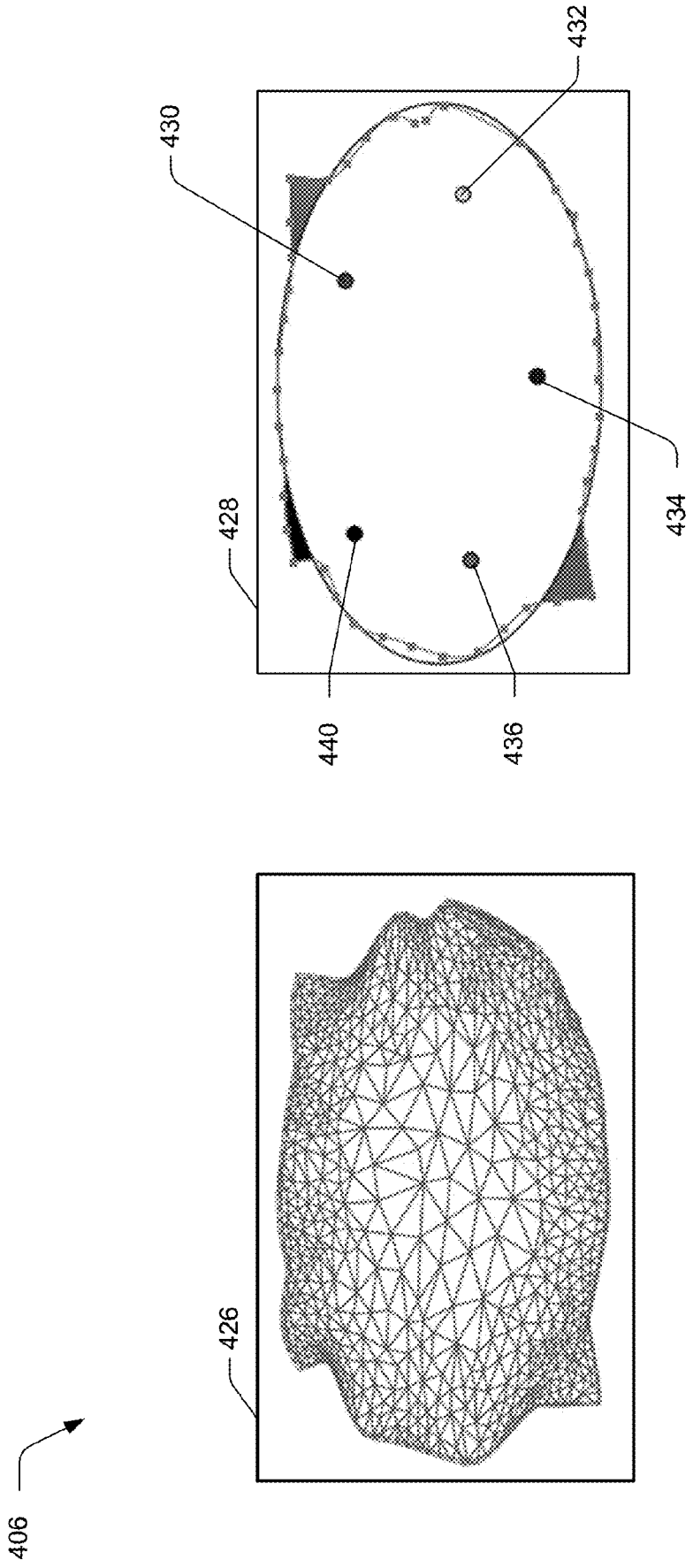
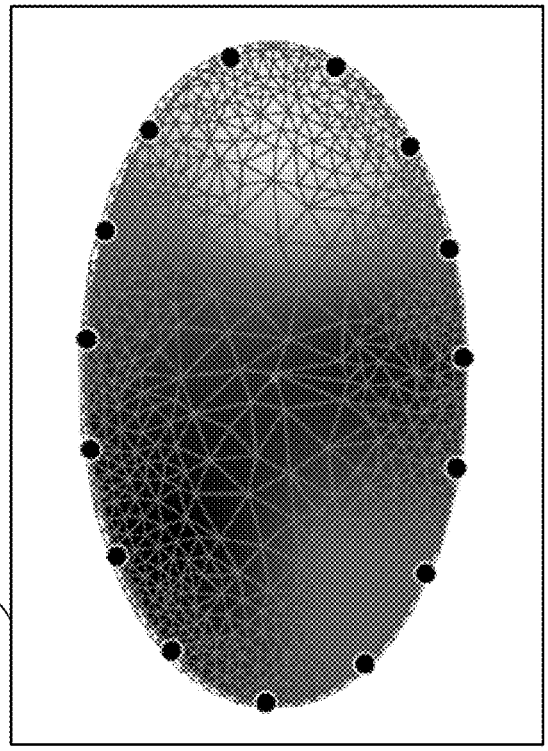
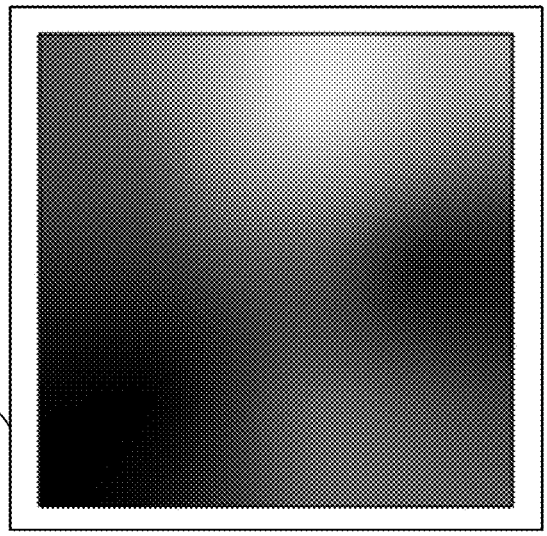


Fig. 4D





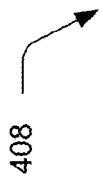


Fig. 4B

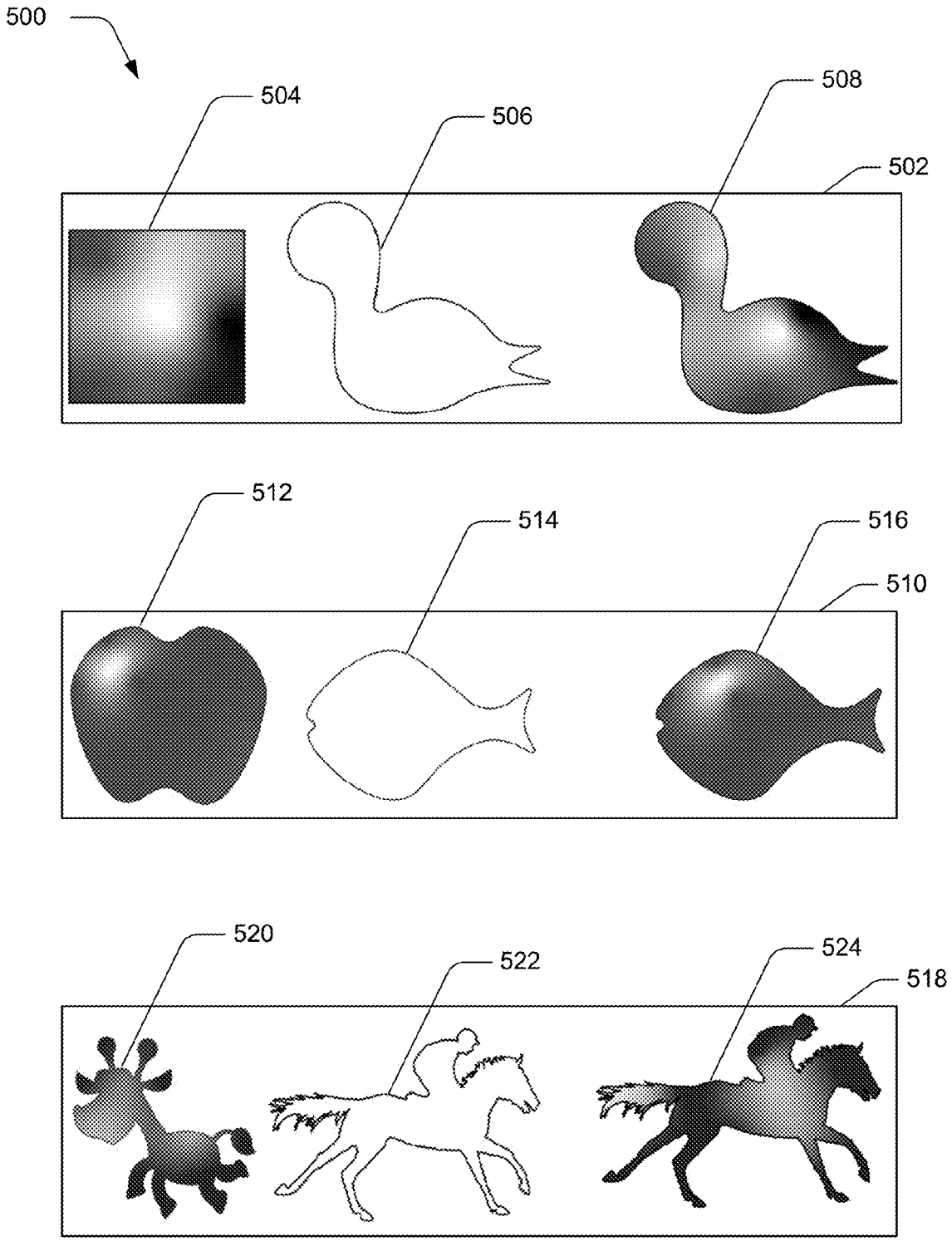


Fig. 5

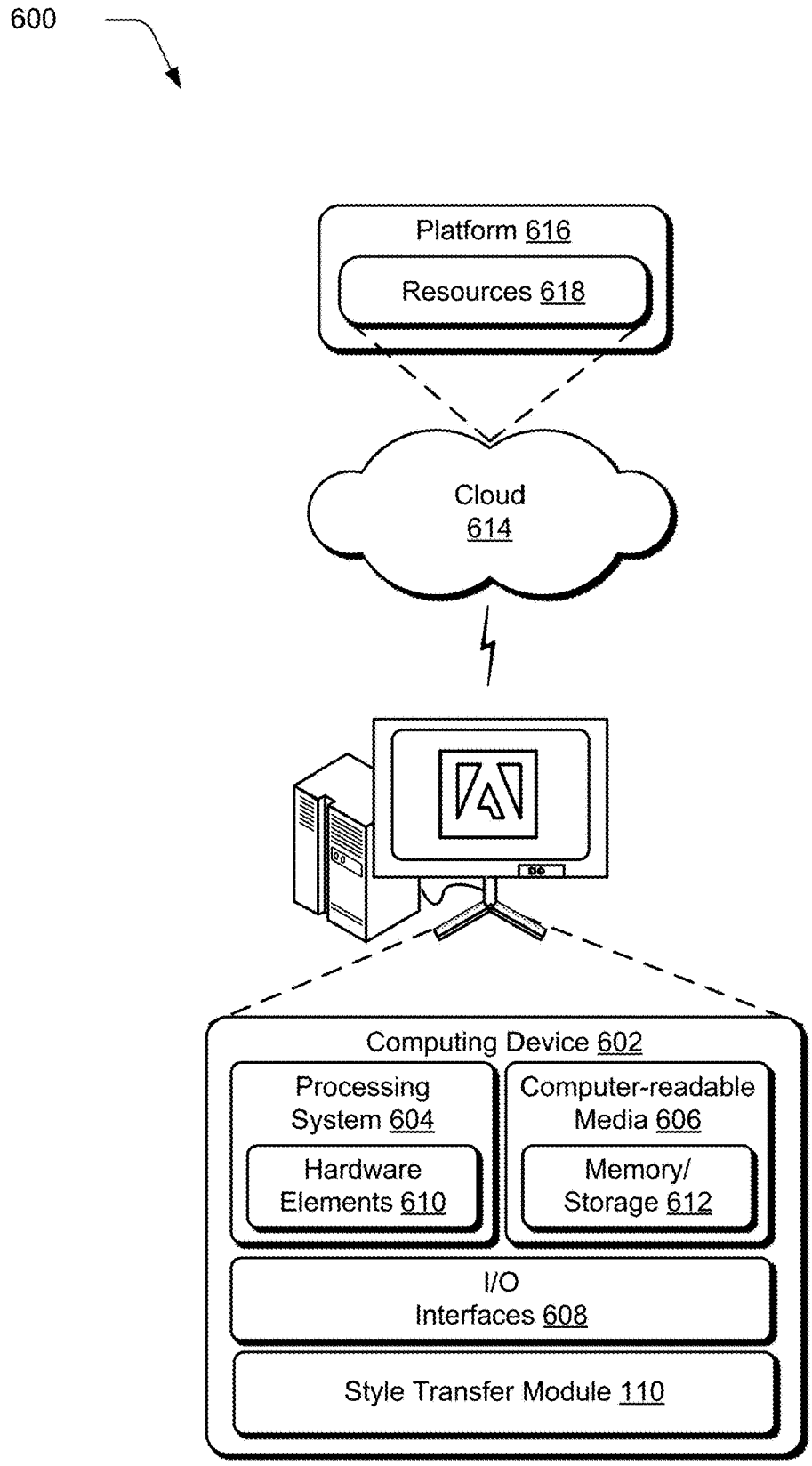

600
Platform 616
Resources 618
Cloud
614
Computing Device 602
Processing
System 604
Hardware
Elements 610
Computer-readable
Media 606
Memory/
Storage 612
I/O
Interfaces 608
Style Transfer Module 110

Fig. 6

FREEFORM GRADIENT STYLE TRANSFER

BACKGROUND

In digital drawing and painting systems, a gradient is generally a blending of colors or shades of colors which is rendered in a user interface. Conventional systems can render gradients for use as colorful backgrounds, special effects, project themes, presentation styles, etc. Some types of gradients can be designed as a digital asset which may be used to apply the gradient, for example, to fill geometries of various digital objects. In this manner, conventional systems enable a digital artist to design a gradient such as a by manipulation of color points which control the colors of the gradient, and then the gradient design can be applied to many other objects. This allows the digital artist to propagate the gradient design across multiple objects quickly and efficiently.

Freeform gradients are a type of gradient that can be used to create a blend of colors within a geometry of an object in an ordered or random sequence such that the blending appears smooth and natural. These gradients are created by arranging color points on a mesh of an object. Each color point has an associated color value, and conventional systems use the color values to interpolate colors to generate the freeform gradients within the geometry of the object. However, freeform gradients are object specific and therefore cannot be applied to other objects as is the case with linear and radial gradients. This is frustrating to digital artists as they must attempt to recreate a freeform gradient of a source object in a target object to transfer a style of the freeform gradient from the source object to the target object. Accordingly, the inability to transfer freeform gradient styles among digital objects presents a technological problem in the field of digital drawing and painting.

SUMMARY

Systems and techniques are described for freeform gradient style transfer. A computing device implements a style transfer system which receives a source geometry of an object having a freeform gradient and a target geometry of an additional object as inputs. The freeform gradient has a style defined by orientations of color point locations within the source geometry of the object. The system adds source mesh handles to a boundary of a source mesh of the object, and the system also adds target mesh handles to a target mesh of the additional object. The system also preserves the color point locations of the source mesh.

The source mesh handles are mapped to the target mesh handles, and the system warps the source mesh to appear as the target geometry based on the mapping. The preserved color point locations of the source mesh are mapped to the warped source mesh and a freeform gradient having the style is generated based on this mapping. By warping the source mesh to appear as the target geometry and mapping the preserved color point locations to the warped source mesh, the system transfers the style of the freeform gradient of the source geometry of the object to the target geometry of the additional object.

The described systems improve digital drawing and painting by technology by enabling freeform gradient style transfer from a source geometry to a target geometry even in cases where the source and target geometries have no features in common. Furthermore, the system is capable of implementing a style of a freeform gradient as a reusable digital asset which can be applied to any geometry of a digital object. This eliminates the tedious effort involved in recreating the style of the freeform gradient each time the style is applied to a geometry of an object, and the reusable digital asset can be modified to modify the style of freeform gradients applied to many geometries of objects automatically. Additionally, by facilitating freeform gradient style transfer, the described systems provide functionality that was previously not possible.

This Summary introduces a selection of concepts in a simplified form that are further described below in the Detailed Description. As such, this Summary is not intended to identify essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the Office upon request and payment of the necessary fee.

The detailed description is described with reference to the accompanying figures. Entities represented in the figures may be indicative of one or more entities and thus reference may be made interchangeably to single or plural forms of the entities in the discussion.

FIG. **1** is an illustration of an environment in an example implementation that is operable to employ digital systems and techniques as described herein.

FIG. **2** depicts a system in an example implementation showing operation of a style transfer module.

FIG. **3** is a flow diagram depicting a procedure in an example implementation in which a style of a freeform gradient of a source geometry is transferred to a target geometry.

FIGS. **4**A, **4**B, **4**C, **4**D, and **4**E are illustrations depicting an example representation in which a style of a freeform gradient of a source geometry is transferred to a target geometry.

FIG. **5** is an illustration depicting three example representations of freeform gradient style transfer.

FIG. **6** illustrates an example system that includes an example computing device that is representative of one or more computing systems and/or devices that may implement the various techniques described herein.

DETAILED DESCRIPTION

Overview

Broadly, a gradient is a blending of colors or shades of colors which is rendered in a user interface on a display device. Conventional systems can render gradients for use as backgrounds, special effects, project themes, presentation styles, etc. Some types of gradients can be designed as a digital asset which may be used to apply the gradient, for example, to fill geometries of various digital objects. In this manner, conventional systems enable a digital artist to design a gradient such as a by manipulation of color points which control the colors of the gradient, and then the gradient design can be applied to many other objects. This allows the digital artist to propagate the gradient design across multiple objects quickly and efficiently.

Freeform gradients are a type of gradient that can be used to create a blend of colors within a geometry of an object in an ordered or random sequence such that the blending appears smooth and natural. These gradients are created by arranging color points on a mesh of an object. Each color

point has an associated color value, and conventional systems use the color values to interpolate colors to generate the freeform gradients within the geometry of the object. In this manner, freeform gradients are object specific and therefore cannot be applied to other objects as is the case with other types of gradients such as linear and radial gradients. This is frustrating to digital artists as they must attempt to recreate a style of a freeform gradient of a source object in a target object to transfer the style of the freeform gradient to the target object. Accordingly, the inability to transfer freeform gradient styles among digital objects presents a technological problem in the field of digital drawing and painting.

To overcome these problems, techniques are described that support freeform gradient style transfer within a digital medium environment. In accordance with the described techniques, a computing device implements a style transfer system which receives a source geometry of an object having a freeform gradient and a target geometry of an additional object as inputs. The freeform gradient has a style defined by orientations of color point locations within the source geometry of the object.

The style transfer system includes a meshing module, a mesh handle module, a mapping module, and a warping module. The meshing module is implemented to add anchor points to the source geometry and the target geometry, and then generate a source mesh of the object and a target mesh of the additional object. The addition of the anchor points causes both the source mesh and the target mesh to have more path segments which increases precision in mesh deformation. The meshing module adds the anchor points such that the source mesh and the target mesh have the same number of anchor points to ensure one-to-one correspondence between the meshes. Color point locations of the source mesh are also identified and the meshing module preserves mesh indices associated with the color point locations of the source mesh.

The mesh handle module is implemented to sample points around a boundary of the source mesh and sample points around a boundary of the target mesh. Based on the sampled points, the mesh handle module adds mesh handles to the source mesh boundary and the target mesh boundary. These mesh handles are added to the meshes such that the source mesh and the target mesh have an equal number of mesh handles to facilitate a one-to-one mapping between mesh handles of the two meshes.

The mapping module is implemented to map the mesh handles of the source mesh to the mesh handles of the target mesh. To accomplish this, the mapping module coincides a geometrical center of the source mesh and a geometrical center of the target mesh and maps an initial mesh handle of the source mesh to an initial mesh handle of the target mesh and the initial mesh handle of the source mesh is modified to have the position of the corresponding initial mesh handle of the target mesh. The mapping module continues mapping the source mesh handles to the target mesh handles in this way until each of the mesh handles of the source mesh have the position of the corresponding mesh handle of the target mesh.

The warping module is implemented to warp the source mesh based on the mesh handle mapping so that the warped source mesh appears as the target geometry. The color point locations are mapped, e.g., by the mapping module, to the warped source mesh based on the preserved mesh indices and a freeform gradient is generated based on the mapped color point locations. In this way, the style transfer system transfers the freeform gradient style of the source geometry of the object to the target geometry of the additional object.

The described systems improve digital drawing and painting by technology by enabling freeform gradient style transfer from a source geometry to a target geometry even in cases where the source and target geometries have no features in common. Furthermore, the system is capable of implementing a style of a freeform gradient as a reusable digital asset which can be applied to any geometry of a digital object. This eliminates the tedious effort involved in recreating the style of the freeform gradient each time the style is applied to a geometry of an object, and the reusable digital asset can be modified to modify the style of freeform gradients applied to many geometries of objects automatically. Additionally, by facilitating freeform gradient style transfer, the described systems provide functionality that was previously not possible.

In the following discussion, an example environment is first described that may employ the techniques described herein. Example procedures are also described which may be performed in the example environment as well as other environments. Consequently, performance of the example procedures is not limited to the example environment and the example environment is not limited to performance of the example procedures.

Example Environment

FIG. **1** is an illustration of an environment **100** in an example implementation that is operable to employ digital systems and techniques as described herein. The illustrated environment **100** includes a computing device **102** connected to a network **104**. The computing device **102** may be configured as a desktop computer, a laptop computer, a mobile device (e.g., assuming a handheld configuration such as a tablet or mobile phone), and so forth. Thus, the computing device **102** may range from a full resource device with substantial memory and processor resources (e.g., personal computers, game consoles) to a low-resource device with limited memory and/or processing resources (e.g., mobile devices). Additionally, the computing device **102** may be representative of a plurality of different devices, such as multiple servers utilized by a business to perform operations "over the cloud."

The illustrated environment **100** also includes a display device **106** that is communicatively coupled to the computing device **102** via a wired or a wireless connection. A variety of device configurations may be used to implement the computing device **102** and/or the display device **106**. The computing device **102** includes a storage device **108** and a style transfer module **110**. The storage device **108** is illustrated to include digital content **112**.

An example of the digital content **112** is a freeform gradient applied to a geometry of an object **114** which is displayed in a user interface **116** on the display device **106**. This freeform gradient has a style defined by orientations of color points within the object's **114** geometry. In an example, the freeform gradient style of the object **114** is transferable to another object which is illustrated as a freeform gradient having the style applied to a geometry of an additional object **118** that is also displayed in the user interface **116**. In particular, the geometry of the object **114** is different than the geometry of the additional object **118**. In this example, the freeform gradient style is applied to a square-shaped geometry of the object **114**, and the freeform gradient style is transferred to a dragon-shaped geometry of the additional object **118**.

Aspects of the freeform gradient style as applied to the geometry of the object **114** may be included in input data **120**. The style transfer module **110** is illustrated as having, receiving, and/or transmitting input data **120**. For example,

the computing device **102** may implement the style transfer module **110** to receive the input data **120** which can include the style of the freeform gradient applied to the geometry of the object **114** as well as the geometry of the additional object **118**, and the style transfer module **110** can process the input data **120** to transfer the style of the freeform gradient from the square-shaped geometry of the object **114** to the dragon-shaped geometry of the additional object **118**.

In one example, the style of the freeform gradient applied to the geometry of the object **114** may be included within the system **100** as digital content **112**. In this manner, the style of the freeform gradient can be a digital asset that is usable to apply the style of the freeform gradient to the geometry of the additional object **118**. In this example, the input data **120** may only include the geometry of the additional object **118**, and the style transfer module **110** is implemented to transfer the freeform gradient style of the object **114** to the additional object **118** by transferring the style from a reusable digital asset to the additional object **118**.

FIG. **2** depicts a system **200** in an example implementation showing operation of a style transfer module **110**. The style transfer module **110** is illustrated to include a meshing module **202**, a mesh handle module **204**, a mapping module **206**, and a warping module **208**. The computing device **102** implements the style transfer module **110** to receive input data **120**, e.g., the style transfer module **110** may receive the input data **120** over the network **104** or based on user inputs received by the computing device **102** via the user interface **116**. In one or more implementations, the meshing module **202** may receive the input data **120** and the meshing module **202** may process the input data **120** as source mesh data **210**, target mesh data **212**, and color point location data **214**. For example, the meshing module **202** may receive the freeform gradient applied to the geometry of the object **114** as part of receiving the input data **120**, and the meshing module **202** is implemented to generate a source mesh of the object **114** which is represented by the source mesh data **210**. In an example, the meshing module **202** is implemented to add anchor points to the source mesh of the object **114** because adding these anchor points will create more path segments of the source mesh. As a result the additional path segments, the source mesh may be warped with greater precision.

In one or more implementations, the input data **120** may include the geometry of the additional object **118**. For example, the meshing module **202** can receive the geometry of the additional object **118** as part of receiving the input data **120**, and the meshing module **202** is implemented to generate a target mesh of the additional object **118** which is represented by the target mesh data **212**. In one example, the meshing module **202** is implemented to add anchor points to the target mesh of the additional object **118** to increase warping precision. In another example, the meshing module **202** is implemented to add anchor points to the source mesh of the object **114** and target mesh of the additional object **118** such that the source mesh and the target mesh have the same fixed number of anchor points. In this manner, the meshing module **202** prepares the source mesh and the target mesh for processing by the mesh handle module **204**.

In an example, the input data **120** may include locations of color points of the freeform gradient applied to the geometry of the object **114**. The meshing module **202** can receive the locations of the color points of the freeform gradient of the object **114** as part of receiving the input data **120**, and the meshing module **202** is implemented to preserve vertex indices for color points of the source mesh of the object **114** which is represented as the color point location data **214**.

The mesh handle module **204** is illustrated as receiving the source mesh data **210** and the target mesh data **212**. In one or more implementations, the mesh handle module **204** receives the source mesh data **210** and the target mesh data **212** as inputs, and the mesh handle module **204** is implemented to process the inputs as source mesh handle data **216** and target mesh handle data **218**. For example, the mesh handle module **204** is implemented to process the source mesh data **210** to add mesh handles to the source mesh which is represented as the source mesh handle data **216**. The source mesh data **210** describes the source mesh of the object **114** having the additional anchor points and the target mesh data **212** describes the target mesh of the additional object **118** also having the additional anchor points. For example, the mesh handle module **204** may receive the source mesh data **210**, and the mesh handle module **204** is implemented to sample boundary points of the geometry of the object **114**. In an example, the mesh handle module **204** may receive the target mesh data **212**, and the mesh handle module **204** is implemented to sample boundary points of the geometry of the additional object **118**.

In one or more implementations, the mesh handle module **204** is implemented to determine a starting segment as the first segment index to sample to get one-to-one correspondence between the source mesh and the target mesh. For example, the mesh handle module **204** is implemented to add mesh handles on the sampled boundary points of the geometry of the object **114**. In one example, the mesh handle module **204** can be implemented to determine mesh index positions of the color point locations of the freeform gradient of the geometry of the object **114**. In this example, the mesh handle module **204** is implemented to analyze each closed loop of segments of the source mesh of the object **114**. For example, the source mesh of the object **114** may be a triangle mesh, so in this example, the mesh handle module **204** is implemented to analyze each triangle of the source mesh and return the triangle index if a color point is in the triangle or return the nearest triangle index from the color point position such as by calculating a distance of the color point from the triangle.

In an example, the mesh handle module **204** is implemented to add mesh handles on the sampled boundary points of the geometry of the object **114** and the sampled boundary points of the geometry of the additional object **118**. In one example, the geometry of the additional object **118** with added mesh handles is represented as the target mesh handle data **218**. In this manner, the mesh handle module **204** adds the mesh handles to the source mesh and the target mesh so that the meshes have the same number of mesh handles to facilitate a one-to-one mapping between the mesh handles of the source mesh and the mesh handles of the target mesh. For example, the mesh handle module **204** is implemented to determine a mesh handle of the first segment index to start sampling as a starting mesh handle to perform the one-to-one mapping. In one or more implementations, the starting mesh handle to perform the one-to-one mapping is included as part of the source mesh handle data **216**.

The mapping module **206** is illustrated as receiving the source mesh handle data **216**, the target mesh handle data **218**, and the color point location data **214**. For example, the mapping module **206** receives the source mesh handle data **216**, the target mesh handle data **218**, and the color point location data **214** as inputs, and the mapping module **206** is implemented to process the inputs as handle mapping data **220** and color point mapping data **222**. In an example, the mapping module **206** may be configured to add the mesh handles to the target mesh of the additional object **118**.

In one or more implementations, the mapping module **206** receives the source mesh handle data **216** and the target mesh handle data **218**, and the mapping module **206** is implemented to map the mesh handles of the source mesh of the object **114** to the mesh handles of the target mesh of the additional object **118**. In this way, the mapping module **206** is configured to coincide a geometric center of the geometry of the object **114** with a geometric center of the geometry of the additional object **118**, and then map the mesh handles of the source mesh to the mesh handles of the target mesh by a one-to-one mapping. As a result, the mapping module **206** translates the geometry of the object **114** to the geometry of the additional object **118** such that the mesh handles of the source mesh are modified to have a position of the corresponding mesh handles of the target mesh which is represented as the handle mapping data **220**.

In an example, the mapping module **206** receives the color point location data **214**, and the mapping module **206** is implemented to map the color point locations based on the modified source mesh positions and the mesh index positions of the color point locations of the freeform gradient of the geometry of the object **114**. This color point location mapping is represented as the color point mapping data **222**. In one example, the color point mapping data **222** describes color point positions of the source mesh after the source mesh is warped based on the handle mapping data **220**.

The warping module **208** is illustrated as receiving the handle mapping data **220** and the color point mapping data **222** as inputs, and the warping module **208** is implemented to process the inputs to warp the source mesh to the target mesh and map the color point positions to the warped source mesh to transfer the style of the freeform gradient of the object **114** to the additional object **118** as a freeform gradient having the style. In this way, the warping module **208** warps the geometry of the object **114** to appear as the geometry of the additional object **116** based on the handle mapping data **220**, and the warping module **208** maps the color point locations from the preserved indexes of the source mesh to corresponding indexes of the warped source mesh to transfer the style of the freeform gradient of the object **114** to the additional object **118**. As a result, the style transfer module **110** receives the input data **120** which can include the style of the freeform gradient applied to the geometry of the object **114** as well as the geometry of the additional object **118**, and the style transfer module **110** can process the input data **120** to transfer the style of the freeform gradient from the square-shaped geometry of the object **114** to the dragon-shaped geometry of the additional object **118**.

In general, functionality, features, and concepts described in relation to the examples above and below may be employed in the context of the example procedures described in this section. Further, functionality, features, and concepts described in relation to different figures and examples in this document may be interchanged among one another and are not limited to implementation in the context of a particular figure or procedure. Moreover, blocks associated with different representative procedures and corresponding figures herein may be applied together and/or combined in different ways. Thus, individual functionality, features, and concepts described in relation to different example environments, devices, components, figures, and procedures herein may be used in any suitable combinations and are not limited to the particular combinations represented by the enumerated examples in this description.

Example Procedures

The following discussion describes techniques that may be implemented utilizing the previously described systems and devices. Aspects of each of the procedures may be implemented in hardware, firmware, software, or a combination thereof. The procedures are shown as a set of blocks that specify operations performed by one or more devices and are not necessarily limited to the orders shown for performing the operations by the respective blocks. In portions of the following discussion, reference will be made to FIG. **1** and FIG. **2**.

FIG. **3** is a flow diagram depicting a procedure **300** in an example implementation in which a style of a freeform gradient of a source geometry is transferred to a target geometry. Source mesh handles are generated on a boundary of a source mesh of a source geometry, and the source mesh includes color point locations of a freeform gradient of the source geometry (block **302**). Target mesh handles are generated on a boundary of a target mesh of a target geometry (block **304**). For example, the mesh handle module **204** generates the source mesh handles on the boundary of the source mesh, and the mesh handle module **204** also generates the target mesh handles on the boundary of the target mesh. The source mesh handles are mapped to the target mesh handles by coinciding a geometric center of the source geometry and a geometric center of the target geometry (block **306**). In an example, the mapping module **206** maps the source mesh handles to the target mesh handles. The source mesh and the color point locations are warped based on the mapping to generate a freeform gradient of the target geometry having a style of the freeform gradient of the source geometry (block **308**). In one example, the warping module **208** warps the source mesh and the color point locations to generate the freeform gradient of the target geometry having the style of the source geometry. The freeform gradient of the target geometry having the style is rendered in a user interface (block **310**). In one or more implementations, the computing device **102** renders the freeform gradient of the target geometry in the user interface **116** on the display device **106**.

Freeform Gradient Style Transfer

FIGS. **4**A, **4**B, **4**C, **4**D, and **4**E are illustrations depicting an example representation in which a style of a freeform gradient of a source geometry is transferred to a target geometry. FIG. **4**A depicts an illustration of an example representation **400** of an object having a freeform gradient style of a source geometry to be transferred, and an additional object having a target geometry to receive the transferred style. FIG. **4**B depicts an illustration of an example representation **402** of anchor points added to the source geometry and anchor points added to the target geometry. FIG. **4**C depicts an illustration of an example representation **404** of source mesh handles added to a source mesh of the source geometry and target mesh handles added to a target mesh of the target geometry. FIG. **4**D depicts an illustration of an example representation **406** of a warped source mesh and mapped and/or warped color point positions. FIG. **4**E illustrates an example representation **408** of a freeform gradient style transfer from the source geometry of the object to the target geometry of the additional object.

Representation **400** is illustrated to include a freeform gradient of a source geometry of a source object **410** as well as a target geometry of an additional object **412**. As shown in FIG. **4**A, the geometry of the source object **410** is generally square and the geometry of the additional object **412** is generally an ellipse. Additionally, the freeform gradient of the source geometry has a distinct style which is defined by colors and orientations of color point locations within the source geometry. The techniques described herein can transfer the freeform gradient from the square geometry

of the object **410** to the ellipse geometry of the additional object **412** while preserving the style of the freeform gradient of the object **410**.

Representation **402** is also illustrated to include the freeform gradient of the source geometry of the source object **410** and the target geometry of the additional object **412**. As shown in FIG. **4**B, a plurality of anchor points **414** are added to the source geometry and a plurality of anchor points **416** are added to the target geometry. Addition of anchor points **414** and **416** ensures a precise deformation of the source geometry because the additional anchor points will add additional segments to meshes as illustrated in FIG. **4**C. In an example, the number of anchor points **414** of the source geometry is the same as the number of anchor points **416** of the target geometry to facilitate one-to-one correspondence between the meshes shown in FIG. **4**C.

Representation **404** is illustrated to include a source mesh **418** of the source geometry and a target mesh **420** of the target geometry. As shown in FIG. **4**C, source mesh handles **422** have been added to the boundary of the source mesh **418** and target mesh handles **424** have been added to the boundary of the target mesh **420**. In one example, the number of source mesh handles **422** of the source mesh **418** is the same as the number of target mesh handles **424** of the target mesh **420** to facilitate one-to-one mapping of the source mesh handles **422** to the target mesh handles **424**.

Representation **406** includes a warped source mesh **426** and mapped color point locations **428**. As shown in FIG. **4**D, the warped mesh **426** is the source mesh **418** deformed based on mapping the source mesh handles **422** to the target mesh handles **424**. In this way, the warped mesh **426** is representative of the source geometry of the source object **410** warped to appear as the target geometry of the additional object **112**. The mapped color point locations **428** include color point locations **430**-**440** which have been mapped from the color point locations of the source mesh **418** to the warped source mesh **426**. By mapping the color point locations **228** to the warped mesh **426** which resembles the target geometry of the additional object **412**, the style of the freeform gradient of the source geometry of the object **410** is transferred to the target geometry of the additional object **412**. This is illustrated by representation **408** which includes the freeform gradient of the source geometry of the source object **410** which has a freeform gradient style and a freeform gradient of the target geometry of the additional object **442** which also has the freeform gradient style.

FIG. **5** is an illustration **500** depicting three example representations of freeform gradient style transfer. A first example **502** is illustrated to include a freeform gradient of a source geometry **504** having a first style and a target geometry **506** to receive a freeform gradient having the first style. In this example, the source geometry **504** is generally a square shape and the target geometry **506** resembles a shape of a sitting bird. As shown in FIG. **5**, the target geometry **507** receives a freeform gradient having the first style which is illustrated as freeform gradient style transfer **508** in example **502**.

A second example **510** is also is illustrated to include a freeform gradient of a source geometry **512** having a second style and a target geometry **514** to receive a freeform gradient having the second style. In this second example, the source geometry **512** resembles the shape of an apple and the target geometry **514** resembles the shape of a fish. As shown in FIG. **5**, the target geometry **514** receives a freeform gradient having the second style which is illustrated as freeform gradient style transfer **516** in example **510**.

A third example **518** is also is illustrated to include a freeform gradient of a source geometry **520** having a third style and a target geometry **522** to receive a freeform gradient having the third style. In this third example, the source geometry **520** resembles the shape of a cow and the target geometry **522** resembles the shape of a jockey riding a horse. As shown in FIG. **5**, the target geometry **522** receives a freeform gradient having the third style which is illustrated as freeform gradient style transfer **524** in example **518**.

Although, these examples have been described in terms of freeform gradient style transfer from a source geometry to a target geometry, the described systems and techniques are further capable of applying a freeform gradient style from a reusable digital asset any target geometry. In this way, the described systems are capable of implementing a style of a freeform gradient as a reusable digital asset which can be applied to any geometry of a digital object. This eliminates the tedious effort involved in recreating the style of the freeform gradient each time the style is applied to a geometry of an object, and the reusable digital asset can be modified to modify the style of freeform gradients applied to many geometries of objects automatically. By way of example, the freeform gradient of the source geometry **504** having a first style can be a reusable digital asset that is capable of applying the first style to the target geometry **514** or the target geometry **522**. In this manner, the freeform gradient of the source geometry **512** having the second style can be saved as a digital asset which is usable to apply the second style to the target geometry **506** or the target geometry **522**. Similarly, the freeform gradient of the source geometry **520** having the third style can be saved as a digital asset which is usable to apply the third style to the target geometry **506** or the target geometry **514**.

Example System and Device

FIG. **6** illustrates an example system **600** that includes an example computing device that is representative of one or more computing systems and/or devices that may implement the various techniques described herein. This is illustrated through inclusion of the style transfer module **110**. The computing device **602** may be, for example, a server of a service provider, a device associated with a client (e.g., a client device), an on-chip system, and/or any other suitable computing device or computing system.

The example computing device **602** as illustrated includes a processing system **604**, one or more computer-readable media **606**, and one or more I/O interfaces **608** that are communicatively coupled, one to another. Although not shown, the computing device **602** may further include a system bus or other data and command transfer system that couples the various components, one to another. A system bus can include any one or combination of different bus structures, such as a memory bus or memory controller, a peripheral bus, a universal serial bus, and/or a processor or local bus that utilizes any of a variety of bus architectures. A variety of other examples are also contemplated, such as control and data lines.

The processing system **604** is representative of functionality to perform one or more operations using hardware. Accordingly, the processing system **604** is illustrated as including hardware elements **610** that may be configured as processors, functional blocks, and so forth. This may include implementation in hardware as an application specific integrated circuit or other logic device formed using one or more semiconductors. The hardware elements **610** are not limited by the materials from which they are formed or the processing mechanisms employed therein. For example, processors

may be comprised of semiconductor(s) and/or transistors (e.g., electronic integrated circuits (ICs)). In such a context, processor-executable instructions may be electronically-executable instructions.

The computer-readable storage media **606** is illustrated as including memory/storage **612**. The memory/storage **612** represents memory/storage capacity associated with one or more computer-readable media. The memory/storage component **612** may include volatile media (such as random access memory (RAM)) and/or nonvolatile media (such as read only memory (ROM), Flash memory, optical disks, magnetic disks, and so forth). The memory/storage component **612** may include fixed media (e.g., RAM, ROM, a fixed hard drive, and so on) as well as removable media (e.g., Flash memory, a removable hard drive, an optical disc, and so forth). The computer-readable media **606** may be configured in a variety of other ways as further described below.

Input/output interface(s) **608** are representative of functionality to allow a user to enter commands and information to computing device **602**, and also allow information to be presented to the user and/or other components or devices using various input/output devices. Examples of input devices include a keyboard, a cursor control device (e.g., a mouse), a microphone, a scanner, touch functionality (e.g., capacitive or other sensors that are configured to detect physical touch), a camera (e.g., which may employ visible or non-visible wavelengths such as infrared frequencies to recognize movement as gestures that do not involve touch), and so forth. Examples of output devices include a display device (e.g., a monitor or projector), speakers, a printer, a network card, tactile-response device, and so forth. Thus, the computing device **602** may be configured in a variety of ways as further described below to support user interaction.

Various techniques may be described herein in the general context of software, hardware elements, or program modules. Generally, such modules include routines, programs, objects, elements, components, data structures, and so forth that perform particular tasks or implement particular abstract data types. The terms "module," "functionality," and "component" as used herein generally represent software, firmware, hardware, or a combination thereof. The features of the techniques described herein are platform-independent, meaning that the techniques may be implemented on a variety of commercial computing platforms having a variety of processors.

An implementation of the described modules and techniques may be stored on or transmitted across some form of computer-readable media. The computer-readable media may include a variety of media that may be accessed by the computing device **602**. By way of example, and not limitation, computer-readable media may include "computer-readable storage media" and "computer-readable signal media."

100581 "Computer-readable storage media" may refer to media and/or devices that enable persistent and/or non-transitory storage of information in contrast to mere signal transmission, carrier waves, or signals per se. Thus, computer-readable storage media refers to non-signal bearing media. The computer-readable storage media includes hardware such as volatile and non-volatile, removable and non-removable media and/or storage devices implemented in a method or technology suitable for storage of information such as computer readable instructions, data structures, program modules, logic elements/circuits, or other data. Examples of computer-readable storage media may include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, hard disks, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other storage device, tangible media, or article of manufacture suitable to store the desired information and which may be accessed by a computer.

"Computer-readable signal media" may refer to a signal-bearing medium that is configured to transmit instructions to the hardware of the computing device **602**, such as via a network. Signal media typically may embody computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as carrier waves, data signals, or other transport mechanism. Signal media also include any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared, and other wireless media.

As previously described, hardware elements **610** and computer-readable media **606** are representative of modules, programmable device logic and/or fixed device logic implemented in a hardware form that may be employed in some embodiments to implement at least some aspects of the techniques described herein, such as to perform one or more instructions. Hardware may include components of an integrated circuit or on-chip system, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a complex programmable logic device (CPLD), and other implementations in silicon or other hardware. In this context, hardware may operate as a processing device that performs program tasks defined by instructions and/or logic embodied by the hardware as well as a hardware utilized to store instructions for execution, e.g., the computer-readable storage media described previously.

Combinations of the foregoing may also be employed to implement various techniques described herein. Accordingly, software, hardware, or executable modules may be implemented as one or more instructions and/or logic embodied on some form of computer-readable storage media and/or by one or more hardware elements **610**. The computing device **602** may be configured to implement particular instructions and/or functions corresponding to the software and/or hardware modules. Accordingly, implementation of a module that is executable by the computing device **602** as software may be achieved at least partially in hardware, e.g., through use of computer-readable storage media and/or hardware elements **610** of the processing system **604**. The instructions and/or functions may be executable/operable by one or more articles of manufacture (for example, one or more computing devices **602** and/or processing systems **604**) to implement techniques, modules, and examples described herein.

The techniques described herein may be supported by various configurations of the computing device **602** and are not limited to the specific examples of the techniques described herein. This functionality may also be implemented all or in part through use of a distributed system, such as over a "cloud" **614** as described below.

The cloud **614** includes and/or is representative of a platform **616** for resources **618**. The platform **616** abstracts underlying functionality of hardware (e.g., servers) and software resources of the cloud **614**. The resources **618** may include applications and/or data that can be utilized while computer processing is executed on servers that are remote from the computing device **602**. Resources **618** can also

include services provided over the Internet and/or through a subscriber network, such as a cellular or Wi-Fi network.

The platform **616** may abstract resources **618** and functions to connect the computing device **602** with other computing devices. The platform may also serve to abstract scaling of resources to provide a corresponding level of scale to encountered demand for the resources that are implemented via the platform. Accordingly, in an interconnected device embodiment, implementation of functionality described herein may be distributed throughout the system **600**. For example, the functionality may be implemented in part on the computing device **602** as well as via the platform **616** that abstracts the functionality of the cloud **614**.

CONCLUSION

Although the implementation of freeform gradient style transfer has been described in language specific to structural features and/or methods, it is to be understood that the appended claims are not necessarily limited to the specific features or methods described. Rather, the specific features and methods are disclosed as example implementations freeform gradient style transfer, and other equivalent features and methods are intended to be within the scope of the appended claims. Further, various different examples are described and it is to be appreciated that each described example can be implemented independently or in connection with one or more other described examples.

What is claimed is:

1. In a digital medium environment to transfer a style of a freeform gradient of a source geometry to a target geometry, a method implemented by a computing device, the method comprising:

generating, by the computing device, source mesh handles on a boundary of a source mesh of the source geometry, the source mesh including color point locations of the freeform gradient;

generating, by the computing device, target mesh handles on a boundary of a target mesh of the target geometry;

mapping, by the computing device, the source mesh handles to the target mesh handles by coinciding a geometric center of the source geometry and a geometric center of the target geometry;

warping, by the computing device, the source mesh and the color point locations based on the mapping to generate a freeform gradient of the target geometry having the style; and

rendering, by the computing device, the freeform gradient of the target geometry having the style in a user interface.

2. The method as described in claim **1**, further comprising:

adding a plurality of anchor points to the source geometry wherein the source geometry and the target geometry have a same number of anchor points; and

generating the source mesh of the source geometry.

3. The method as described in claim **1**, wherein the mapping is a one-to-one mapping.

4. The method as described in claim **1**, further comprising mapping the color point locations from the source mesh to the target mesh.

5. The method as described in claim **1**, wherein the freeform gradient of the source geometry is a digital asset that is reusable to transfer the style to an additional target geometry.

6. The method as described in claim **1**, wherein the source mesh handles are evenly distributed around the boundary of the source mesh.

7. The method as described in claim **1**, further comprising preserving vertex indices of the source mesh, the vertex indices corresponding the color point locations for mapping the color point locations from the vertex indices to the target mesh.

8. The method as described in claim **1**, further comprising:

sampling points around the boundary of the source mesh; and

using the points to add the source mesh handles to the source mesh.

9. The method as described in claim **1**, wherein a number of source mesh handles is equal to a number of target mesh handles.

10. In a digital medium environment to transfer a style of a freeform gradient of a source geometry to a target geometry, a system comprising:

a mesh handle module implemented to:

add source mesh handles to a source mesh of the source geometry, the source mesh including color point locations of the freeform gradient; and

add target mesh handles to a target mesh of the target geometry;

a mapping module implemented to map the source mesh handles to the target mesh handles by coinciding a geometric center of the source geometry and a geometric center of the target geometry; and

a warping module implemented to warp the source mesh and the color point locations based on the mapping to generate a freeform gradient of the target geometry having the style.

11. The system as described in claim **10**, further comprising a meshing module implemented to:

add a plurality of anchor points to the source geometry wherein the source geometry and the target geometry have a same number of anchor points; and

generate the source mesh of the source geometry.

12. The system as described in claim **10**, wherein the mapping module is implemented to map the color point locations from the source mesh to the target mesh.

13. The system as described in claim **10**, wherein the freeform gradient of the source geometry is a digital asset that is reusable to transfer the style to an additional target geometry.

14. The system as described in claim **10**, wherein the mesh handle module is implemented to:

sample points around the boundary of the source mesh; and

use the points to add the source mesh handles to the source mesh.

15. The system as described in claim **10**, wherein a number of source mesh handles is equal to a number of target mesh handles.

16. In a digital medium environment to transfer a style of a freeform gradient of a source geometry to a target geometry, a system comprising:

means for mapping source mesh handles of a source mesh of the source geometry to target mesh handles of a target mesh of the target geometry;

means for warping the source mesh to the target geometry using the target mesh handles;

means for mapping color point locations of the freeform gradient to the target mesh based on the warping; and

means for generating a freeform gradient of the target geometry having the style.

17. The system as described in claim 16, wherein the freeform gradient of the source geometry is a digital asset that is reusable to transfer the style to an additional target geometry.

18. The system as described in claim 16, further comprising means for adding a plurality of anchor points to the source geometry wherein the source geometry and the target geometry have a same number of anchor points.

19. The system as described in claim 16, wherein a number of source mesh handles is equal to a number of target mesh handles.

20. The system as described in claim 16, further comprising:

means for sampling points around the boundary of the source mesh; and

means for using the points to add the source mesh handles to the source mesh.

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